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Oil Flow Optimization by Using PertafloSIM - Software Developed by Pertamina Upstream Research & Technology Innovation (URTI)

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Abstract. A study has been conducted to analyze and optimize the performance of the pipeline system using PertafloSIM - Software Developed by Pertamina Upstream Research & Technology Innovation (URTI). The case study used is an oil mixture from the Rantau Field and Pangkalan Susu Pertamina EP Asset-1 which is flowed through onshore and offshore pipes for shipment by tanker. It was reported from the field that there was a pressure drop that was quite large that could potentially cause damage to pumping equipment. To prevent such conditions, an optimum pumping system is needed. The first step is carried out by entering the data reported from the field such as pipe length, inside diameter, outside diameter, elevation and roughness, both for onshore, offshore, flexible hoses, and floating hoses leading to the tanker into PertafloSIM software, as well as oil flow rate, temperature, API Gravity of 50 API oil, loading pump pressure (upstream), and SPM pressure (downstream). From the results of the base case study, it was found that the bottleneck occurred in the flexi hose pipe which has a significant pressure drop and fluid velocity of more than 15 ft/s.

Furthermore, various pipeline system optimization scenarios are carried out, including by replacing the existing flexi hose pipe with two sets of flexi hose pipe each 12 inch in diameter, two sets of flexi hose pipe each 6 inch and 12 inch in diameter, and two sets of flexi hose pipe each 6 inch in diameter. From all of these optimization scenarios, "two steps of flexi hose pipe each 6-inch and 12-inch in diameter" is the best and profitable scenario because only to continue using the existing 6-inch diameter flexi hose coupled with 1 series of 12-inch flexi hose pipe, this will be useful for increasing capacity, increasing reliability, and there is a spare flexi hose pipe if one of them leaks / breaks, so it is also beneficial from an economic aspect. All the results of this studies show that PertafloSIM is able to calculate fluid flow in the pipe accurately and reliable for optimizing fluid flow in the pipe.

Keyword: PertafloSIM, Optimization, Pipeline System

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1 Introduction

Rantau and Pangkalan Susu Field are the onshore fields owned by Pertamina EP Asset-1, located on the northern part of Sumatra Island, Indonesia (Figure 1). Oil from the Rantau Field is flowed to the Pangkalan Susu field so that it collects together with the Pangkalan Susu field oil. Then the oil mixture is flowed by a 13 km pipe (ID = 20 inch) to the gathering station on the beach, all these processes are carried out onshore. Furthermore, every two months an oil lifting of 134,863 BBL is carried out from the gathering station to the tanker with the offshore pipe as far as 17 Km (OD = 32 inch; ID = 30 inch), Flexible Hose pipe (OD = 6.625 inch; ID = 6") and Floating Hose Pipe (OD =12.75 inch; ID =12") to maintain the continuity of the lifting so that the oil pumping system and pipeline network must be in reliable condition, this is done to prevent pump failure (leakage / pump damage). However, it was reported from the field that there was a pressure drop that was quite large that could potentially cause damage to pumping equipment. To prevent such conditions, an optimum pumping system is needed (relatively low pressure drop between the discharge pump and the output to the tanker). Therefore, a study is needed to predict the accuracy of the pressure drop in the pumping system using pipeline simulation, after study conducted later on there will be the parametric study to find the most optimum of pumping system. Details of the case study pipeline system can be seen in figure 2.

The objective of this paper is to study the capabilities of PertafloSIM (Version 2.1.0) - Software developed by Pertamina Upstream Research & Technology Innovation in calculating fluid flow in pipes, conduct pressure drop calculations based on current field flowing conditions and conduct the parametric studies to optimize the pipeline system.

Figure 1. Location of Pangkalan Susu and Rantau Field

Figure 2. Pipeline System

2 Methodology

The first step is carried out by entering the data reported from the field such as pipe length, inside diameter, outside diameter, elevation and roughness, both for onshore, offshore, flexible hoses, and floating hoses leading to the tanker into PertafloSIM software, as well as oil flow rate, temperature, API Gravity of 50 API oil, loading pump pressure (upstream), and SPM pressure (downstream). For this case study, the loading pump pressure (upstream) will be set as 'calculated' and SPM pressure as a 'fixed pressure' due to data reported from the field. The PertafloSIM module called "Multiphase Black-Oil" was used in this case study. The base case study is run and an analysis is carried out on the pipeline segmentation area that have a significant pressure drop and fluid velocity of more than 15 ft/s (ASME B31.4, 2002), which indicates a bottleneck.

Furthermore, several scenarios for debottlenecking optimization are carried out to minimize pressure drop and fluid velocity to below 15 ft/s. The flow chart of the methodology used can be seen in Figure 3. The network model, pipeline segmentation, pipeline schematic profile, loading pump, and SPM input data can be seen in figure 4, table 1, figure 5, and figure 6 respectively.

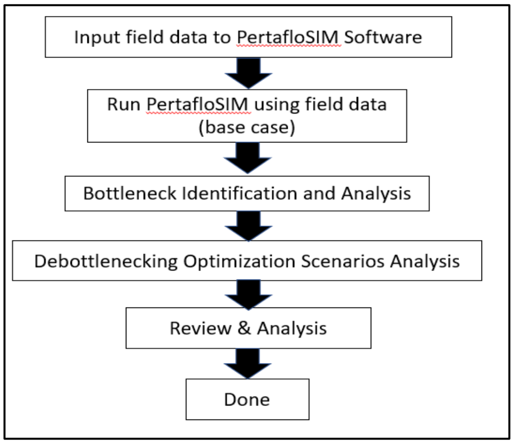


Figure 3. Methodology Flow Chart

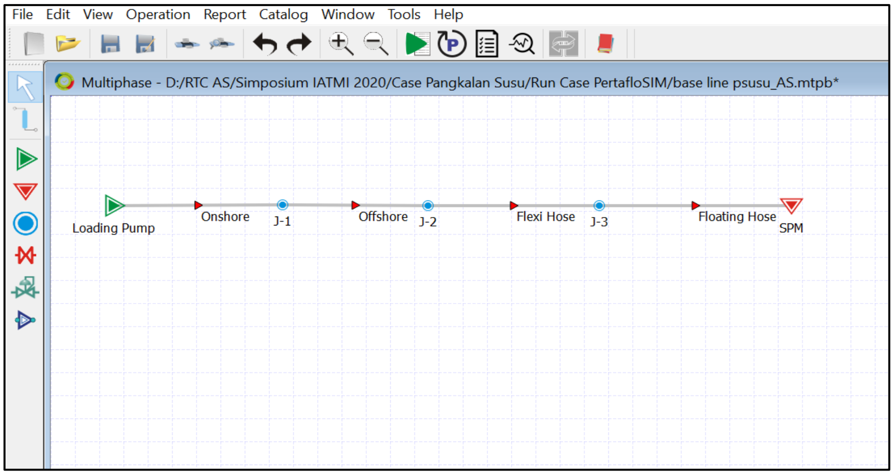


Figure 4. PertafloSIM Network Model

Table 1. Pipeline Segmentation Data

Name	Distance	Elevation	Length	Elevation Change	Outside Diameter	Inside Diameter	Wall Thickness	Roughness	Ambient Temperature	Subsegment Number	U-value
	m	m	m	m	in	in	in	in	C		BTU/h/ft2/F
	0	5									
Onshore Pipe	13000	5	13000	0	22	20.5	0.75	0.0018	30	5	0.2
Onshore Pipe	13700	-20	700	-25	22	20.5	0.75	0.0018	15	5	0.2
Offshore Pipe	31200	-20	17500	0	32	30	1	0.0018	15	5	0.2
Flexible Hose Pipe	31250	0	50	20	6.625	6	0.3125	0.0018	15	5	0.2
Floating Hose	31480	0	230	0	12.75	12	0.375	0.0018	15	5	0.2

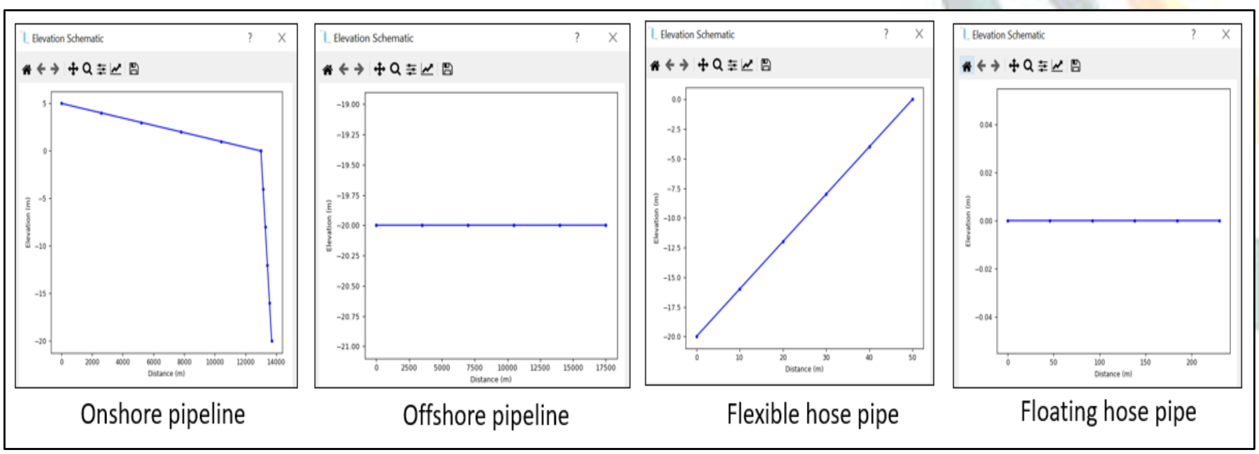
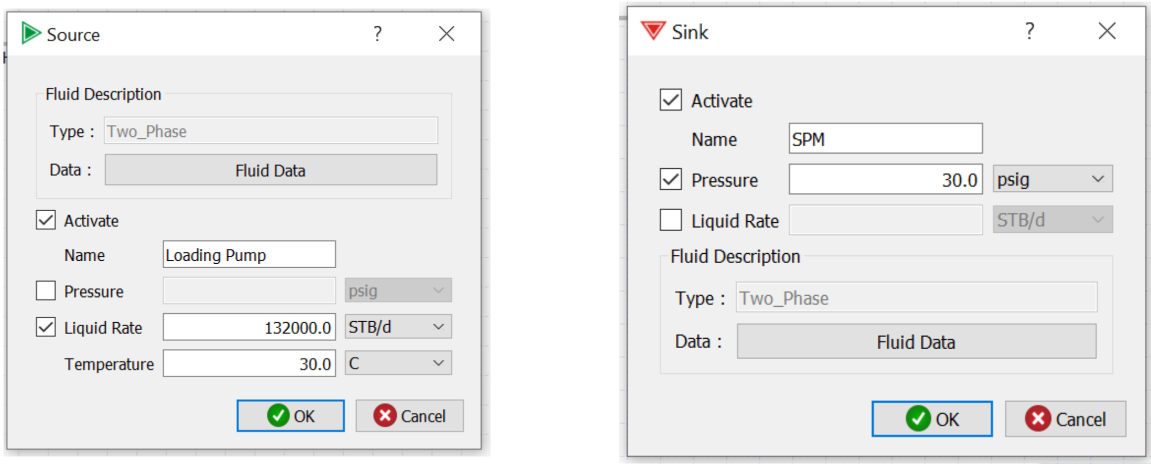


Figure 5. Pipeline Schematic Profile



(a) (b)

Figure 6. (a) Loading Pump Data (Upstream) Input; (b) SPM Data (Downstream) Input.

3 Result and Discussion

The results of the base case study are shown in Table 2, where it can be seen that from the results of fluid velocity and pressure drop in each pipeline segmentation, the bottleneck is indicated to occur in the flexi hose pipe. So that the debottlenecking analysis will be focused on the flexi hose pipe.

Table 2. Pipeline Base Case Results

Name	Type	Inlet	Outlet	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Temperature	Outlet Temperature	Inlet Liquid Superficial Velocity	Outlet Liquid Superficial Velocity
-	-	-	-	psig	psig	psig	C	C	ft/s	ft/s
Flexi Hose	Flowline	J-2	J-3	137.67	38.52	99.16	23.79	23.69	45.80	45.10
Floating Hose	Flowline	J-3	SI-1	38.52	30.00	8.52	23.69	23.67	11.27	11.26
Offshore Pipe	Flowline	J-1	J-2	145.60	137.67	7.93	28.13	23.79	1.84	1.83
Onshore Pipe	Flowline	Loading Pump	J-1	168.54	145.60	22.93	30.00	28.13	3.97	3.94

Figure 7 is the result of the sensitivity analysis between the change in the diameter of the flexi hose pipe to the result of the loading pump pressure, where it can be seen that the optimum diameter of the flexi hose pipe is around 12 inches. Table 3 shows the detailed results using a flexi hose diameter of 12 inches, where compared to the results of the base case study, the resulting pressure drop on the flexi hose pipe is lower and the fluid velocity is below 15 ft / s.

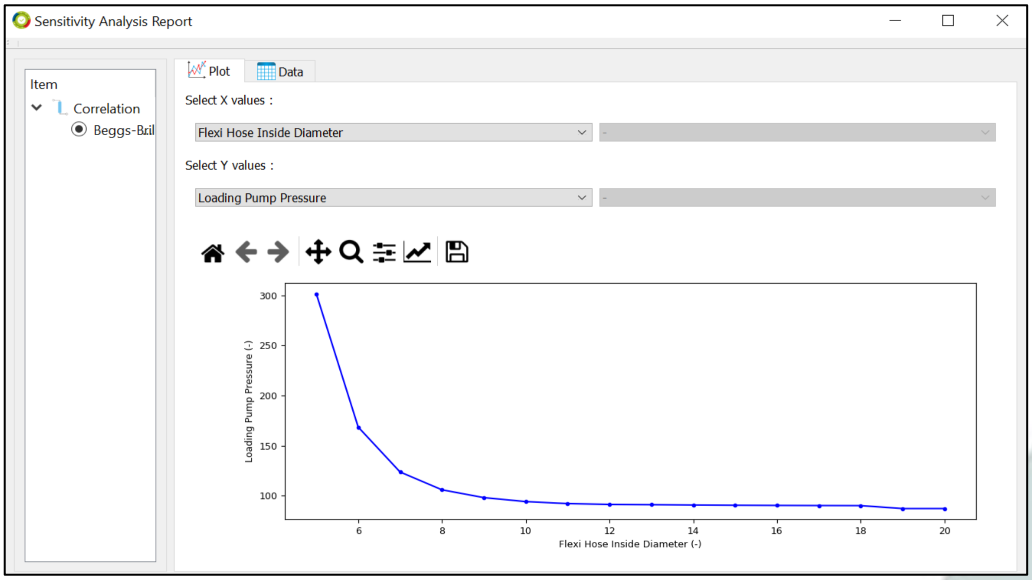


Figure 7. Sensitivity Analysis Result (Flexi Hose Diameter vs Loading Pump Pressure)

Table 3. Pipeline Results (Flexi Hose Pipe Diameter = 12 inch)

Name	Type	Inlet	Outlet	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Temperature	Outlet Temperature	Inlet Liquid Superficial Velocity	Outlet Liquid Superficial Velocity
-	-	-	-	psig	psig	psig	C	C	ft/s	ft/s
Flexi Hose	Flowline	J-2	J-3	60.93	38.52	22.41	23.79	23.69	11.31	11.27
Floating Hose	Flowline	J-3	SI-1	38.52	30.00	8.52	23.69	23.67	11.27	11.26
Offshore Pipe	Flowline	J-1	J-2	68.81	60.93	7.88	28.13	23.79	1.82	1.81
Onshore Pipe	Flowline	Loading Pump	J-1	91.33	68.81	22.52	30.00	28.13	3.92	3.90

Furthermore, several additional scenarios are carried out to analyze pipeline performance, namely by replacing the existing flexi hose pipe with:

1. Two sets of flexi hose pipe each 12 inch in diameter
2. Two sets of flexi hose pipe each 6 inch and 12 inch in diameter.
3. Two sets of flexi hose pipe each 6 inch in diameter.

The PertafloSIM network model and pipeline results for each scenario can be seen in Figure 8, Table 4, Figure 9, Table 5, and Figure 10, Table 6.

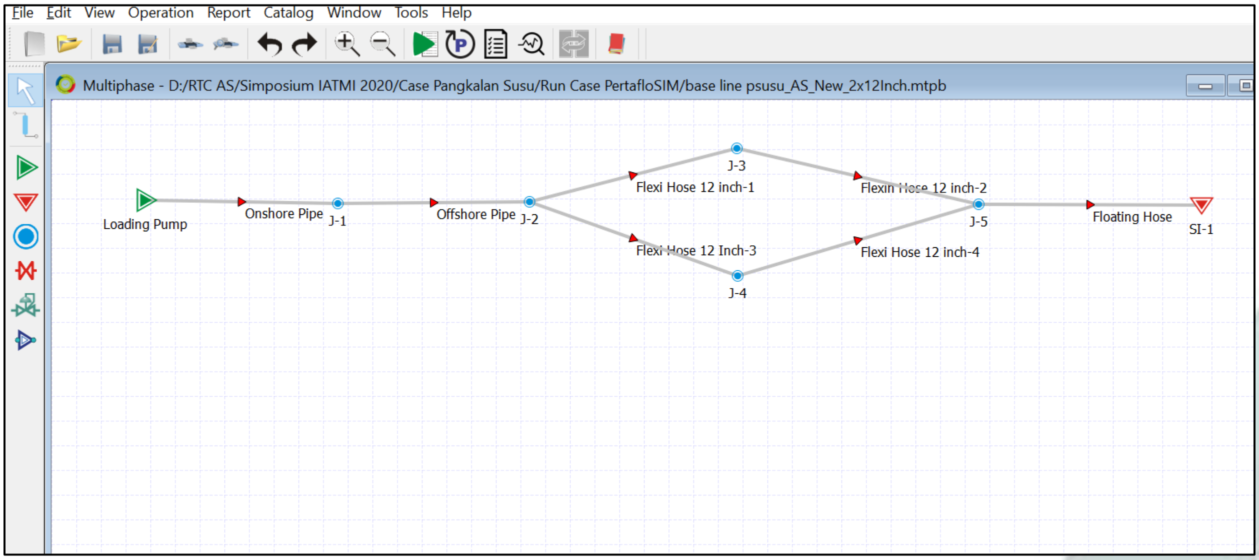


Figure 8. PertafloSIM Network Model (Two Sets of Flexi Hose Pipe each 12-inch in Diameter)

Table 4. Pipeline Results (Two Sets of Flexi Hose Pipe each12 Inch in Diameter)

Name	Type	Inlet	Outlet	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Temperature	Outlet Temperature	Inlet Liquid Superficial Velocity	Outlet Liquid Superficial Velocity
-	-	-	-	psig	psig	psig	C	C	ft/s	ft/s
Flexi Hose 12 Inch-3	Flowline	J-2	J-4	59.97	49.25	10.72	23.79	23.74	5.66	5.65
Flexi Hose 12 inch-1	Flowline	J-2	J-3	59.97	49.25	10.72	23.79	23.74	5.66	5.65
Flexi Hose 12 inch-4	Flowline	J-4	J-5	49.25	38.52	10.73	23.74	23.68	5.65	5.64
Flexih Hose 12 inch-2	Flowline	J-3	J-5	49.25	38.52	10.73	23.74	23.68	5.65	5.64
Floating Hose	Flowline	J-5	SI-1	38.52	30.00	8.52	23.68	23.66	11.27	11.26
Offshore Pipe	Flowline	J-1	J-2	67.85	59.97	7.88	28.13	23.79	1.82	1.81
Onshore Pipe	Flowline	Loading Pump	J-1	90.36	67.85	22.51	30.00	28.13	3.91	3.89

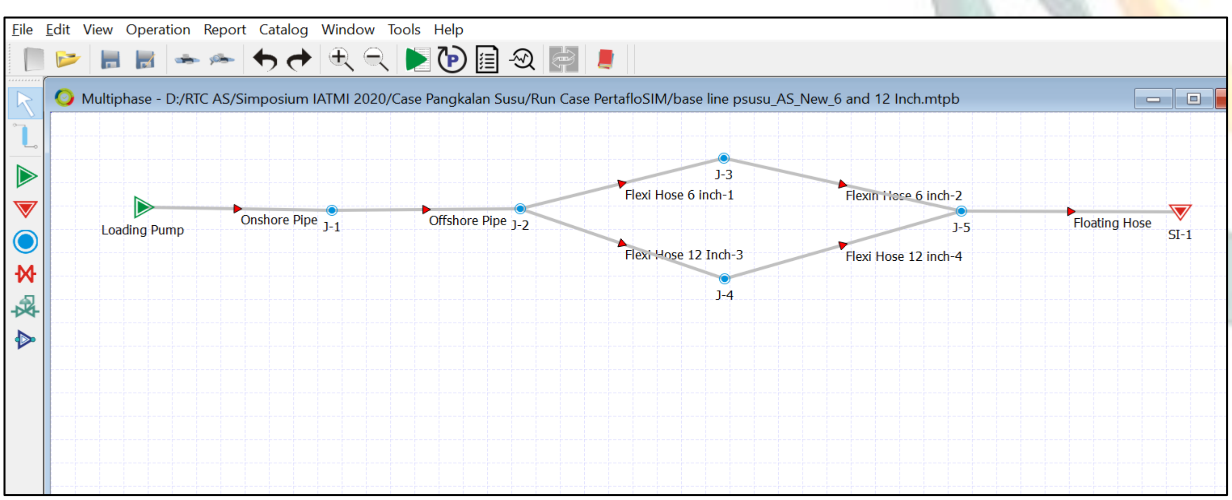


Figure 9. PertafloSIM Network Model (Two Sets of Flexi Hose Pipe each 6 Inch and 12 inch in Diameter)

Table 5. Pipeline Results (Two Sets of Flexi Hose Pipe each 6 Inch and 12 inch in Diameter)

Name	Type	Inlet	Outlet	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Temperature	Outlet Temperature	Inlet Liquid Superficial Velocity	Outlet Liquid Superficial Velocity
-	-	-	-	psig	psig	psig	C	C	ft/s	ft/s
Flexi Hose 6 inch-1	Flowline	J-2	J-3	60.74	49.64	11.11	23.79	23.73	6.11	6.10
Flexi Hose 12 Inch-3	Flowline	J-2	J-4	60.75	49.64	11.11	23.79	23.74	9.78	9.77
Flexi Hose 12 inch-4	Flowline	J-4	J-5	49.64	38.52	11.12	23.74	23.69	9.77	9.75
Flexih Hose 6 inch-2	Flowline	J-3	J-5	49.64	38.52	11.12	23.73	23.68	6.10	6.09
Floating Hose	Flowline	J-5	SI-1	38.52	30.00	8.52	23.69	23.66	11.27	11.26
Offshore Pipe	Flowline	J-1	J-2	68.63	60.75	7.88	28.13	23.79	1.82	1.81
Onshore Pipe	Flowline	Loading Pump	J-1	91.14	68.63	22.52	30.00	28.13	3.92	3.90

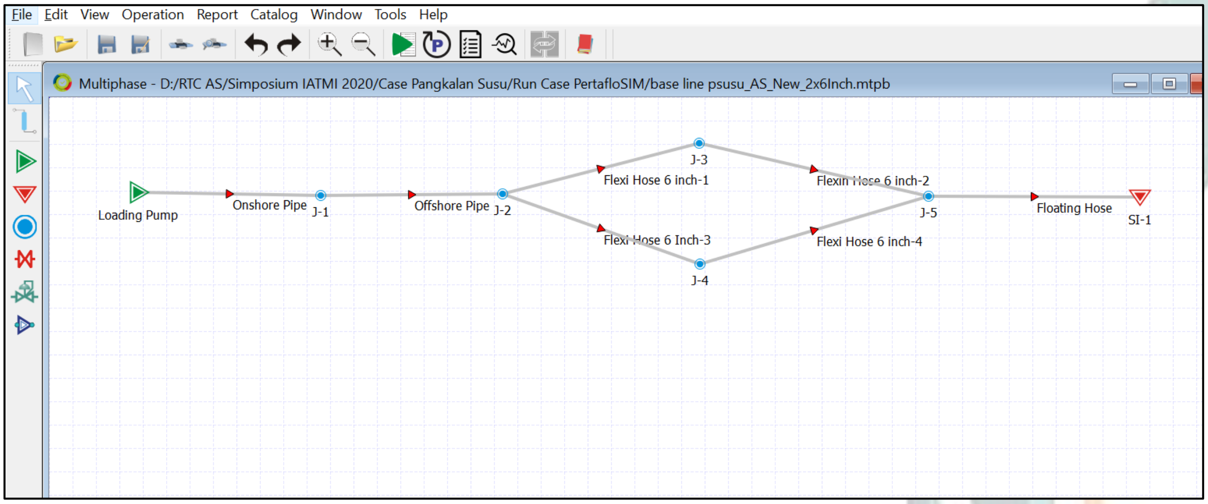


Figure 9. PertafloSIM Network Model (Two Sets of Flexi Hose Pipe each 6 Inch in Diameter)

Table 6. Pipeline Results (Two Sets of Flexi Hose Pipe each 6 Inch in Diameter)

Name	Type	Inlet	Outlet	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Temperature	Outlet Temperature	Inlet Liquid Superficial Velocity	Outlet Liquid Superficial Velocity
-	-	-	-	psig	psig	psig	C	C	ft/s	ft/s
Flexi Hose 12 Inch-3	Flowline	J-2	J-4	77.80	58.16	19.64	23.79	23.74	22.68	22.62
Flexi Hose 12 inch-1	Flowline	J-2	J-3	77.80	58.16	19.64	23.79	23.74	22.68	22.62
Flexi Hose 12 inch-4	Flowline	J-4	J-5	58.16	38.52	19.64	23.74	23.69	22.62	22.55
Flexih Hose 12 inch-2	Flowline	J-3	J-5	58.16	38.52	19.64	23.74	23.69	22.62	22.55
Floating Hose	Flowline	J-5	SI-1	38.52	30.00	8.52	23.69	23.67	11.27	11.26
Offshore Pipe	Flowline	J-1	J-2	85.69	77.80	7.89	28.13	23.79	1.82	1.81
Onshore Pipe	Flowline	Loading Pump	J-1	108.29	85.69	22.60	30.00	28.13	3.93	3.91

From the pipeline results in each scenario, it can be seen that in the scenario of the flexi hose pipe 12 inch (one and two series) and the scenario Two sets flexi hose each 6 Inch and 12 inch in Diameter show the same pressure drop results, as well as the loading pump pressure performance. Whereas in the scenario of two sets flexi hose, 6-inch pressure drop and the resulting loading pump pressure performance is greater than other scenarios.

From these results indicate that the best scenario is to add 1 series of flexi hose with a diameter of 12 inches to the existing flexi hose pipe with a diameter of 6 inches so that 2 sets of flexi hose pipes are used. This scenario can also be the best scenario compared to other scenarios from an economic aspect because it does not require costs to dismantle the existing flexi hose pipe. The summary of the pipeline results for each scenario can be seen in table 7.

Table 7. Pipeline Results Summary for Each Scenarios

	One Sets Flexi Hose 12 inch					Two sets flexi hose 12 inch				
Name	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Velocity	Outlet Velocity	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Velocity	Outlet Velocity
	psig	psig	psig	ft/s	ft/s	psig	psig	psig	ft/s	ft/s
Onshore Pipe Line	91.33	68.81	22.52	3.92	3.90	90.36	67.85	22.51	3.91	3.89
Offshore Pipe Line	68.81	60.93	7.88	1.82	1.81	67.85	59.97	7.88	1.82	1.81
Flexi Hose	60.93	38.52	22.41	11.31	11.27	59.97	38.52	21.45	1.81	11.27
Floating Hose	38.52	30.00	8.52	11.27	11.26	38.52	30.00	8.52	11.27	11.26
	Two sets flexi hose each 6 Inch and 12 inch in Diameter					Two sets flexi hose 6 inch				
Name	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Velocity	Outlet Velocity	Inlet Pressure	Outlet Pressure	Pressure Drop	Inlet Velocity	Outlet Velocity
	psig	psig	psig	ft/s	ft/s	psig	psig	psig	ft/s	ft/s
Onshore Pipe Line	91.14	68.63	22.52	3.92	3.90	108.29	85.69	22.60	3.93	3.91
Offshore Pipe Line	68.63	60.75	7.88	1.82	1.81	85.69	77.80	7.89	1.82	1.81
Flexi Hose	60.75	38.52	22.23	1.81	11.27	77.80	38.52	39.29	1.81	11.27
Floating Hose	38.52	30.00	8.52	11.27	11.26	38.52	30.00	8.52	11.27	11.26

4 Conclusion

A study has been conducted to analyze and optimize the performance of the pipeline system using PertafloSIM - Software Developed by Pertamina Upstream Research & Technology Innovation (URTI). Field data has been inputted including pipeline segmentation, elevation, pipe diameter, flow rate, API gravity, upstream pressure and downstream pressure. Based on the results of the base case with PertafloSIM (confirmed from reports in the field), it shows that there is bottlenecking in the flexi hose pipe which is indicated by a large enough pressure drop with fluid velocities of more than 15 ft / s. Furthermore, from the results of the study of the sensitivity analysis of the flexi hose diameter on the performance of loading pump pressure (upstream), it was found that the optimum diameter of the flexi hose is about 12 inches.

Furthermore, several scenarios are carried out to optimize pipeline performance, and analyzed that the best scenario is to continue using the existing 6-inch diameter flexi hose coupled with 1 series of 12-inch flexi hose pipe, this will be useful for increasing capacity, increasing reliability, and there is a spare flexi hose pipe if one of them leaks / breaks, so it is also beneficial from an economic aspect.

All the results of this studies show that PertafloSIM is able to calculate fluid flow in the pipe accurately and reliable for optimizing fluid flow in the pipe.

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